Probing Exciton Polaritons in van der Waals Materials with Electron Beams

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Strong interactions between radiation and two-level atoms demands strategies for either shrinking the mode volume of the light, or incorporating cavities to enhance the interaction time. The former could be achieved by open-resonator plasmonic systems, or by using near-field probes. Examples of quasi-two-level quantum systems are excitons. Particularly room-temperature excitons in transition metal dichalcogenides have been intensively investigated upon conditions to reach polaritonic effects, as well as polariton-polariton interactions and ultimately condensation. Normally, scanning near-field optical microscopes are used to enhance the interaction of light with even dark excitons. The role of electron beams carrying evanescent fields in exciting two-level systems are less explored. Here, I describe how electron beams and particularly cathodoluminescence spectroscopy can be used to probe exciton polaritons in WSe_2 thin films [1, 2]. Particularly, different mechanisms of radiation, namely, Cherenkov radiation and transition radiation will be discussed. Transition radiation interfere in far field with the exciton polaritons scattered from the edges of the flakes, making it possible to unravel the propagation constant of the exciton polaritons. Cherenkov radiation in contrast, is captured inside thin films and enhance the interaction of photons with excitons, leading to an even larger energy split in the cathodoluminescence spectrum and energy-momentum maps. Furthermore, a novel approach for performing phased-locked photon-electron spectroscopy by merging electron-driven photon sources [3, 4] with electron microscopes is presented and applied to investigate the correlations between A and B excitons in thin films of transition metal dichalcogenides. Our results thus pave the way towards capturing the spatio-spectral distribution of exciton polaritons with a high spatial resolution, using electron beams.

References

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Figures

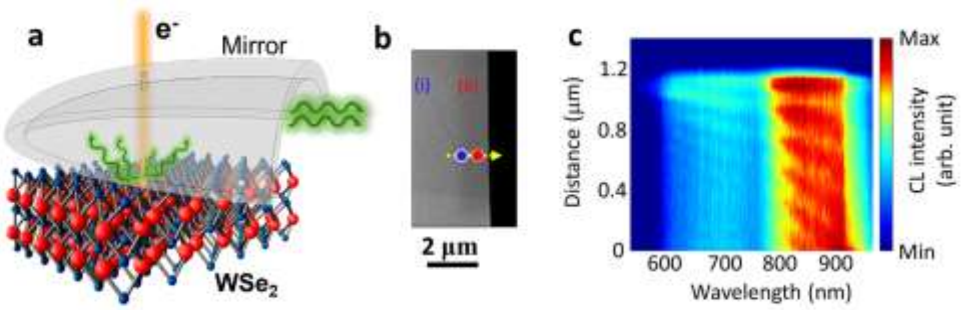

Figure 1: (a) Cathodoluminescence spectroscopy of multilayer WSe_2 flakes (b). (c) Spatial interference fringes due to the interference between the transition radiation and the scattering of exciton polaritons from the edges of the flakes.